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13. ABSTRACT *(Maximum 200 words)*
THIS PROPOSAL DISCUSSES THE APPROACH BY PERSONNEL OF WES TO DETERMINE DESIGN CRITERIA FOR THE MOST TECHNICALLY FEASIBLE INTERIM CONTAINMENT SYSTEMS(S) FOR INSTALLATION AT RMA. WES WAS ASKED ON MAY 17, 1976 TO PREPARE THIS PROPOSAL FOR ADDRESSING THE PLANNING PHASE. THE WORK TO BE DONE DURING THE PLANNING PHASE CONSISTS OF EVALUATING THE TECHNICAL FEASIBILITY OF SEVERAL SYSTEMS AND DETERMINING DESIGN CRITERIA & PRELIMINARY COST ESTIMATES FOR THE MOST FEASIBLE SYSTEM(S). WORK HAS BEEN PERFORMED IN COLLECTING GEOTECHNICAL & CHEMICAL TREATMENT DATA THAT HAVE A BEARING ON PLANNING. THE RESULTS OF THAT WORK ARE SUMMARIZED HEREIN TO PRESENT A BASIS FOR PURSUING THE PROPOSED WORK. SEE RELATED DOCUMENT: RIC #81266R50 INTERIM CONTAINMENT SYSTEM, GROUND WATER TREATMENT, RMA, DENVER, CO, FINAL REPORT. SEPTEMBER 1976.

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WATERWAYS EXPERIMENT STATION, CORPS OF ENG
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

81320R23
ORIGINAL

IN REPLY REFER TO: WESSR

14 MAY 76

SUBJECT: Proposal for Determining Design Criteria for Interim Containment System at Rocky Mountain Arsenal

Project Manager
Chemical Demilitarization
and Installation Restoration (DRCPM-DRR)
Building E4585
Aberdeen Proving Ground, MD 21010

1. In accordance with a verbal request made by members of your staff during a meeting held at the Waterways Experiment Station on 1-2 April 1976, we are submitting a proposal (Incl 1) for determining design criteria for the most technically feasible interim containment system at the Rocky Mountain Arsenal. Work can begin on 1 June 1976 and be completed by 30 September 1976. The associated cost is estimated to be $62,000.

2. If questions arise concerning the proposed work, please contact Mr. Don C. Banks at area code 601; telephone No. 636-3111, ext 2630.

FOR THE DIRECTOR:

F. R. Brown
F. R. BROWN
Engineer
Technical Director

1 Incl
as

Proposal for Determining Design Criteria for
Interim Containment System at Rocky Mountain Arsenal

Introduction and Background

1. In August 1974, the USAE Waterways Experiment Station (WES) responded to a request by the Commander of the Rocky Mountain Arsenal (RMA) to recommend a plan of action for assessing the contamination problem at RMA and developing a remedial program. The plan was used by the RMA as an independent input from which the soundness of in-house plans could be judged.

2. On 19 March 1976, following a series of meetings between personnel of WES and staff members of the Installation Restoration (IR) Program, the WES submitted a statement that described the scope and approach of work to be performed by WES to meet several stated IR needs. Appendix J of the statement addressed long-range studies to apply decontamination technology to the RMA.

3. During a meeting between personnel of WES and IR on 1-2 April 1976, an additional requirement for an interim containment measure at RMA was discussed. In particular, by 30 June 1977, it is desired to have an interim containment measure operational at RMA. The required work for completing an interim containment measure can be divided into four phases: (a) planning, (b) design, (c) contracts, and (d) construction. The WES was asked by 17 May 1976 to prepare this proposal for addressing the planning phase. The work to be done during the planning phase consists of evaluating the technical feasibility of several systems and determining design criteria and preliminary cost estimates for the most feasible system(s).

Scope of Proposal

4. This proposal discusses the approach to be taken by personnel of WES to determine design criteria for the most technically feasible interim containment system(s) for installation at the RMA as well as time and cost estimates. Work has been performed following the

1-2 April 1976 meeting by WES in collecting geotechnical and chemical treatment data that have a bearing on planning for an interim containment system(s). The results of that work are summarized herein to present a basis for pursuing the proposed work.

Constraints to be Placed on Interim Containment Systems

5. The work to be performed under this proposal is directed toward determining design parameters and cost estimates for the most feasible interim containment system(s). The work will be constrained by certain conditions that include but are not necessarily limited to the following:

a. The system must be designed, constructed, and operational by 30 June 1977. As such, time (and funding) will not permit research activities to be pursued; rather existing technological knowledge must be applied to the problem at hand.

b. The system must have a high potential for success.

c. The system must be economically feasible.

d. The system should have the capability of being expanded and/or incorporated into the long-range decontamination program.

e. Any gaps in either geotechnical or treatment data that now exist must be closed prior to a final determination of the most feasible system.

f. The system should quickly produce visible results to show compliance with The Colorado Department of Health's Cease and Desist Order. ? demonstrable, obvious, palpable, tangible(?)

6. With these constraints in mind, it is thought that the most obvious location to site an interim system will be in the bog area along the north boundary since any activity in this area will be quickly evident. The bog comprises a relatively small area and should meet the feasibility requirements of installation time and economy. Available treatment methods and site-specific geologic conditions indicate potential success. Expansion or incorporation of the system into the overall program will be dictated by actual

performance. Other locations will be studied before a final decision is made on siting the interim system. However, descriptions of work contained in this proposal were made with the bog area in mind.

Available Geotechnical Data

7. During March and April 1976, and to the present WES personnel have collected geotechnical data for the RMA and surrounding area from the files of the RMA, the USAE Division, Missouri River, USAE District, Omaha, the U. S. Geological Survey (USGS), the Colorado School of Mines (CSM), and from Dr. N. Timofeeff, consultant to the RMA. The collection of geotechnical data was made to provide information pertaining to both this proposal as well as for the long-range decontamination technology planning (Appendix J; WES letter of 19 March 1976). The data were collected from previous studies of regional and local geology, aquifer reclamation, groundwater, contamination concentrations, and structural foundations.

8. Published reports and maps concerning the regional and local geology-hydrology were obtained from the USGS and Colorado State Geological Survey. In addition, copies of unpublished maps and text representing the latest geological interpretation of the Denver area, including the RMA, were obtained. Original logs of borings drilled by Omaha District for earlier studies were located at the USAE District, Omaha, office and returned to WES for copying. Logs of foundation investigation borings drilled for various structures constructed on the RMA by the Omaha District were also obtained. The geologist that logged the borings was interviewed to determine the drilling and sampling method used and the reasoning used in determining when bedrock had been penetrated. This information is important to interpreting the subsurface conditions and determining the degree of confidence to be placed on the boring data. At the present the depths of the lithologic breaks can be determined

confidently, but some caution must be exercised in determining top of bedrock. Boring logs and samples pertaining to an evaluation of a runway that extends onto the arsenal were obtained from the Stapleton Airport Engineering Department.

9. Logs of the latest set of borings, those by Kal Zeff Associates, were obtained from RMA. All borings are being located on a master map and include the above borings plus water wells logged in an investigation by USGS and the Colorado Water Conservation Board. It is felt that all available borings have been obtained except perhaps others on file with the Well Permit Section of the Colorado Water Conservation Board in Denver. The existence of any such borings will be determined in subsequent telephone contact with the appropriate agency. Another untried possible source of data is the Colorado State Highway Department, which might have boring and laboratory test records.

10. The Colorado School of Mines is currently running geophysical surveys on the arsenal, and data furnished by them will be incorporated into the interpretation of subsurface conditions. Early results indicate that the surveys are distinguishing bedrock and water table accurately and in detail. Additional surveys have been requested for the northern boundary and others subsequently may be desired to fill information gaps elsewhere.

11. Additional site-specific geotechnical data are necessary for any type of interim containment system at any specific location. These additional data should include additional undisturbed, drive, and rock core borings, records of groundwater fluctuations, geophysical profiles, determination of horizontal and vertical permeability within the aquifer, water well pumping tests, quantities of groundwater flow possible for treatment, soil and rock composition, and strength and deformation properties. Most of the additional site-specific geotechnical data can be obtained from the RMA on-going boring program and will be used as a basis to develop and implement an interim demonstration system.

12. Once this proposal is accepted, personnel at WES will work closely with Dr. Timofeeff to assure that drilling and sampling and physical testing are sufficient to meet the needs of the interim containment system.

Available Chemical Treatment Data

13. A review of data on treatment of DIMP and DCPD using conventional sanitary engineering unit processes was made. It was evident from this review that the state-of-the-art for removal of organics in domestic and some industrial waters is reasonably well documented. However, the application of processes such as carbon adsorption, ion exchange, ozonolysis, etc., has not yet been adequately demonstrated on ground and surface waters at RMA to allow the selection of the best practicable treatment method. There is a definite lack of design criteria and operational data which could be used by an A&E firm for designing a treatment system. The U. S. Army Mobility Equipment Research and Development Command (MERADCOM), Fort Belvoir, Virginia, is presently conducting a study for RMA that is attempting to develop some of the needed criteria. The data review indicated that this is the only ongoing work that is specifically addressing the treatability of DIMP and DCPD at RMA.

MERADCOM treatability studies

14. Laboratory studies. The Sanitary Sciences Division, MERADCOM, Fort Belvoir was contacted by the Commander of RMA, during June and July 1975, for the purpose of developing a plan to conduct a treatability study on the bog water at RMA. The objective of the study was to determine the applicability of various sanitary engineering unit processes (carbon adsorption, reverse osmosis, ion

exchange and chemical oxidation) for the removal or destruction of trace organics in the bog water. At the same time it was envisioned that scale-up of the most promising processes would be addressed in a continuing phase of the study.

15. Results of the MERADCOM treatability study showed that powdered carbon/coagulation was the most effective interim method of treating the bog water. Bench scale doses of carbon (2.0 g/l) and a coagulant polymer (1.0 mg/l), were effective in removing approximately 87 percent of the Total Organic Carbon (TOC). Additionally, reverse osmosis using a polyamide 300 membrane was found to be almost equally effective in removing TOC (approximately 80 percent). Granular carbon adsorption, as well as ion exchange resins, were assessed as only marginally acceptable methods, because of suboptimum removal efficiencies and higher costs when compared to powdered carbon. Only limited bench scale work was done with ozonation; however, it proved highly effective in destroying the trace organics in the bog water. Approximately 170 grams of ozone ~~was~~ were needed to remove 1 gram of TOC. It was concluded that additional studies were needed to identify if any toxic compounds were resulting from ozonation.

16. Based on the preliminary treatability studies, MERADCOM recommended that pilot studies needed to be performed at RMA using the powdered carbon/coagulation process and reverse osmosis system.

17. <u>Field studies</u>. Field studies were initiated at RMA during February 1976 and will continue for approximately six months. Pilot carbon/coagulation and reverse osmosis units were shipped to RMA and set up to treat the bog water. To date the units have been operated for approximately five weeks with varying degrees of success. It appears from a preliminary review of four weeks of data that the powdered carbon adsorption/coagulation unit is capable of removing DIMP to levels less than 0.5 ppb. Is this true ? Evidently yes, See para 19

18. Influent concentrations of DIMP and DCPD to the unit have averaged 350 ppb and less than 10 ppb, respectively. An initial carbon dose of 1600 mg/l (HYDRO DARCO-C) with a polymer dose of 8 mg/l

(CATFLOC) was used based on results of the treatability study. Flow to the system is averaging 7 gpm (≈ 3,360 gallons based on an 8-hour operation) and 10 to 15 gallons of sludge is being produced daily.

19. Since DCPD was not detected in the influent water to the pilot unit, the influent was spiked with 700 ppb DCPD to demonstrate the effectiveness of carbon adsorption/coagulation in the removal of DCPD. To date the system has demonstrated treatment to levels less than 10 ppb (detectable limits) and probably is effecting greater removals. see para 18

& where the more is the detector.

20. From the above discussion it would appear that the application of carbon adsorption/coagulation is the most likely candidate for treatment of DIMP and DCPD if an interim measure requires treatment of surface and/or groundwaters. There are, however, several questions that should be addressed prior to design of such a system.

a. What level of DIMP and DCPD treatment will be required to effectively demonstrate compliance with the Colorado Department of Health (CDH) Cease and Desist Order? Assuming that the CDH will set a numerical standard, it may be valid to consider a level of DIMP $\leq$ 0.5 ppb and DCPD $\leq$ 10 ppb, since these are considered detectable limits within the accuracy of the test procedures. There is also reason to assume that toxicity data might be limiting factors when setting standards. It is a common practice to assume one-tenth of the 96 hour LC_{50} as a numerical standard. Values for DIMP and DCPD are not presently available, but LD_{50} from values for similar compounds (Table 1 and 2) suggest that the process is capable of producing the desired effluent quality.

b. Is the process compatible with the overall plans for IR at RMA? Obviously this should be a consideration in selecting any process, although it is conceivable that an interim measure could also be expendable at the end of its useful life.

c. What are the system economics in terms of capital, operating, and average annual costs? It is recognized that some processes are technically feasible, but with the time and cost constraints at

RMA, they may be economically unacceptable regardless of the political or environmental pressures. This decision however, will have to be made by the PMO, EA, and RMA personnel.

d. What is to be done with the wasted sludge? This is an extremely important question that will have to be answered before final selection of the process is made. Currently the criteria for disposing of the waste coagulant-ladened carbon slurry are not available. Efforts should be made by MERADCOM to address this problem (if they have not intended to do so) and to develop criteria useful to the design engineer when considering sludge handling and disposal techniques such as land filling, fixation, dewatering, or incineration.

e. Will the design criteria being developed by MERADCOM be available by 30 September 1976? Through private communications with LTC Robert Carnahan, MERADCOM, it was estimated that the design criteria and most of the operating variables for the liquid portion of the process would be developed by 30 August 1976. More work will be needed to develop the criteria for sludge disposal. The time required to develop these criteria should be assessed as soon as practicable after 17 May if this system proves to be the best practicable alternative.

Data on ozonation process

21. From the data produced by MERADCOM and that reviewed for industrial application, ozonation is considered a highly attractive organics destruction process. This is evident since ozonation may effect complete oxidation of the organics while rendering the water bacteriologically safe. Perhaps one of the most significant advantages of the process would be that ozonation does not produce a sludge handling or disposal problem. A critical review of the criteria needed for design, time required to produce it, and the overall compatibility with the IR program at RMA will be made after 17 May. It is envisioned that ozonation might be eliminated from consideration as an interim treatment measure (due to lack of identifiable design criteria).

Other processes

22. No other processes for organics removal are considered feasible as interim treatment methods at RMA. This decision is based

upon the scarcity of data available (im most cases no data) for which an assessment of adequacy of design criteria could be made.

Possible Interim System Components

23. The interim solution must incorporate various components into a system that will contain the flow of and reduce the level of contaminants in the groundwater system at any specific location. The completed system must not adversely modify the groundwater in the aquifer beyond the bounds of the RMA. Therefore, the decontaminated groundwater may have to be reintroduced into the aquifer at some point beyond the containment system. Containment components being considered include grout curtains, slurry trenches, and open trenches to bedrock. The contaminated groundwater collection components include wells that fully penetrate the aquifer and open-trench sumps. Treatment components include chemical coagulation/carbon adsorption, ozonation, and dilution. (While not a functional component of the system, operational consideration must be given to disposal of treatment process sludges.) The components by which the treated water may be reintroduced into the aquifer include deep wells beyond the containment area, existing irrigation wells and canals, and surface ponding. Surface diversion of fresh water may be considered for dilution or for immediate aquifer recharge.

Study Approach

24. Immediately after initiation of the study, a request for specific additional geotechnical data will be submitted. These data will be applicable to, and necessary for, the selection and design of any of the various components for containment, dewatering, and aquifer recharge. It is anticipated that, by 1 July 1976, qualitative analyses will have resulted in the selection of two or three feasible combinations of components, and that, by 1 August 1976 (after obtaining the necessary geotechnical data), quantitative analyses will have resulted in the selection of the single most feasible system that complies with the aforementioned constraints. These analyses will

require site visits, data reviews, literature reviews, and consultations with contractors and equipment manufacturers. Following final system selection, treatment components will be incorporated and specific design criteria prepared along with cost estimates of the system for planning purposes.

25. The approach to development of treatment design criteria will include continued and close coordination with MERADCOM, RMA, and Edgewood Arsenal. This coordination will be accomplished through site visits, data reviews and consultation with equipment manufacturers. It is visualized that early in the conduct of work (by end of first month) the treatment candidates will be narrowed to one or two alternatives. The remainder of the study effort will involve the development of site specific criteria that should allow for the design of a system consistent with the interim containment/treatment goal.

Time

26. Interim containment and treatment system design criteria are ~~is~~ possible by 30 September 1976, provided that the program summarized in this proposal is authorized to proceed by 1 June and the additional geotechnical data are provided by 15 July and the design criteria for treatment being developed by MERADCOM are provided by 30 August 1976. A preliminary report presenting all design criteria for the complete interim containment/treatment system will be submitted by 30 September 1976. The final formal report, for record, will be submitted as soon after 30 September as possible.

Funding

27. The required funding to accomplish the work previously described is estimated to be $62,000. This funding budget is detailed as follows:

Salary	
2 engineers, 4 months each	32,000
1 engineer, 2 months	8,000
1 geologist, 2 months	8,000
1 technician, 2 months	4,000
Travel	
4 RMA site visits	
2 manufacture/contractor visits	
2 Edgewood Arsenal visits	
Transportation	2,000
Per diem ($33 x 33 days)	1,000
Ground transportation ($33 x 33 days)	1,000
Final Report	6,000
Total	$62,000

TABLE 1

LD$_{50}$ OF SOME ANTI-CHOLINESTERASE DIMP-LIKE COMPOUNDS

Cpd	Structure	LD$_{50}$(mg/Kg)
Parathion	$(C_2H_5O-)_2 - \overset{O}{\overset{\uparrow}{P}} - O - \phi - NO_2$	5 (oral in rats)
Bidrin	$(CH_3O) - \overset{O}{\overset{\uparrow}{P}} - O - \overset{CH_3}{\overset{\backslash}{C}} = \underset{H}{\underset{\mid}{C}} - \overset{O}{\overset{\parallel}{C}} - N(CH_3)_2$	22 (oral in rats)
Ciodrin	$(CH_3O)_2 - \overset{O}{\overset{\uparrow}{P}} - O - \overset{CH_3}{\overset{\backslash}{C}} = \underset{H}{\underset{\mid}{C}} - \overset{O}{\overset{\parallel}{C}} - O - \overset{CH_3}{\overset{\mid}{C}} - \phi$	125 (oral in rats)
DIFP	$F - \underset{\underset{CH(CH_3)_2}{O}}{\overset{O}{\overset{\uparrow}{P}}} - O - CH(CH_3)_2$	0.28 (iv in Monkey) 72.0 (cutaneous application to mice)
DIMP	$CH_3 - \underset{\underset{CH(CH_3)_2}{O}}{\overset{O}{\overset{\uparrow}{P}}} - OCH(CH_3)_2$	UNKNOWN

SOURCE Merck index, 8th Ed. 1968)

TABLE 2

CRITERIA FOR PUBLIC WATER SUPPLIES
AGRICULTURAL IRRIGATION WATER SUPPLIES AND
IN-STREAM FRESH WATER RECOMMENDED BY EPA IN
WATER QUALITY CRITERIA 1972
(EPA R3 73 033 MARCH 1973)

Parameter	Drinking H_2O (mg/l)	Irrigation H_2O (mg/l)	Fresh H_2O (mg/l)
Cl^-	250	---	---
F^-	1.9	1.0	---
NO_3^-	10	---	---
$SO_4^=$	250	---	---
Aldrin	0.001	---	0.001
Dieldrin	0.001	---	0.005
Endrin	0.0005	---	0.002
DCPD*		---	*

*NOTE: USSR limit for monomer in air - 5 ppm (Merck index, 8th ED. 1968)